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# Use of Portable Instrumentation for the Monitoring of Fugitive Organic Emissions from Hazardous Waste Incinerators

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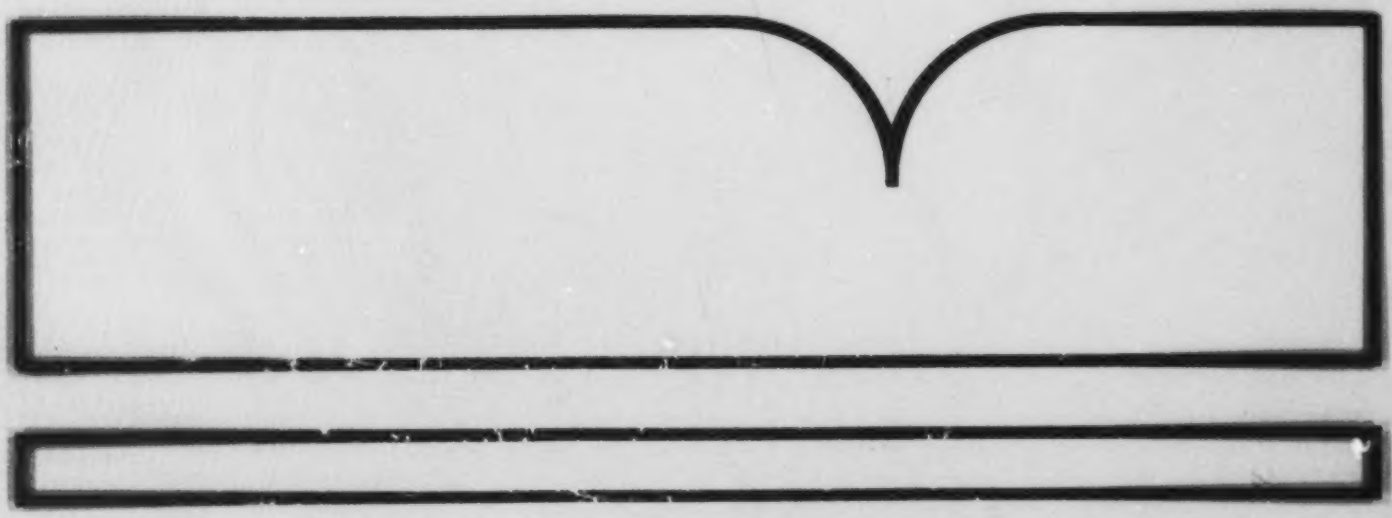

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# THE USE OF PORTABLE INSTRUMENTATION FOR THE MONITORING OF FUGITIVE ORGANIC EMISSIONS FROM HAZARDOUS WASTE INCINERATORS

by

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EPA Contract 68-02-3677, Task 14

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16. ABSTRACT The report gives results of evaluations and tests of currently available portable instrumentation used to monitor fugitive organic emissions generated by the transfer and storage of liquid wastes during the operation of hazardous waste incinerators. Relevant current methodologies were evaluated, and results and recommendations of the evaluations were tested. The evaluation of current methologies for portable volatile organic compound (VOC) monitors, with regard to their applicability in monitoring fugitive organic emissions from hazardous waste incinerators, was completed and is documented as Appendix A of the report. The recommendation was to perform a limited field test with two photoionization analyzers (PIDs) at an operating liquid waste incinerator. A portable flame ionization detector (FID) (for which considerable prior data exists) was to be the reference. Most of the report discusses field tests of the evaluation results at the Cincinnati Municipal Sewer District's incinerator. Test data indicate that, for this application, either a PID containing a 10.2 eV light source or a FID is suitable.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group | |
|---|---|---|---|---|
| Pollution | Organic Compounds | Pollution Control | 13B | 07C |
| Monitors | Portable Instruments | Stationary Sources | 14G | 14B |
| Incinerators | Toxicity | Fugitive Emissions | | 06T |
| Waste Disposal | | Hazardous Waste | | |
| Processing | | | 13H | |
| Leakage | | | | |

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## I. Abstract

The thrust of this task was to evaluate and test currently available portable instrumentation for use in the monitoring of fugitive organic emissions generated by the transfer and storage of liquid wastes during the operation of hazardous waste incinerators. The task was separated into two prime sub-tasks: one involving evaluation of relevant current methodology, and the other to test the results and recommendations of the evaluation.

The initial portion of this task, to evaluate the current methodology for portable volatile organic compound (VOC) monitors with regard to their applicability in monitoring fugitive organic emissions from hazardous waste incinerators, was completed and reported in an interim document in February 1983[1]. The recommendation was to perform a limited field test on two photoionization analyzers (PID's) at an operating liquid waste incinerator. A portable flame ionization detector (FID) (for which considerable prior data exists) was to be used as reference. The second portion of this task, constituting the bulk of this report, are the results of the field testing performed at the Cincinnati Municipal Sewer District incinerator. From the data we conclude that, for this application, either a PID containing a 10.2 eV light source or the FID is suitable.

## II. Introduction

Fugitive organic emissions from trucks off-loading wastes, pump packing glands, valve stems, flanges, tank vents, etc. are of concern at liquid waste incinerators because they can be hazardous to the continued good health of those in the immediate vicinity as well as others (to a lesser degree) further removed. The extent of these emissions is not known nor routinely monitored. Federal Register Method 21, Determination of Volatile Organic Compound Leaks, is designed to address fugitives from organic process equipment but has not been deemed truly suitable for use on hazardous waste incinerators. The wastes delivered to, and combusted by, a liquid waste incinerator vary widely in composition, making any attempt at quantification of fugitive emissions in real time difficult, if not impossible.

A compromise is to utilize an instrument which will respond well to most or all organic vapor in real time, with little operator skill needed, and be sufficiently portable so as not to be an encumbrance while being carried up and down ladders, and in narrow walkways. The photoionization analyzer was considered as a potential candidate to meet these requirements.

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[1] Appendix A

## III. Experimental

### 1) Pre-field Operation

Two photoionization analyzers, (PID's) both HNu Systems Inc. Model PI 101, and a Century Systems FID, Model OVA-128 were to be used in the field portion of this task. One PID had recently been purchased, and the other recently refurbished at the factory. Two new ultraviolet light sources were purchased for use in the PID's. The 11.7 eV light source is relatively new, and was incorporated in this study since it was reported to be more useful for the detection of halogenated organics than the 10.2 eV source. The two new source lamps were conditioned by operating the instruments for several lengthy (12+ hours) periods of time before the span and stability portion of the study was done. The reference instrument, (a flame ionization detector) was new (previously purchased).

An attempt to connect the probes of the two PID's and of the FID into three sides of a Swagelok "cross" fitting with a length of quarter-inch stainless steel tubing as the fourth leg was abandoned when it was observed that the difference in flow rates (2 lpm for the FID, and 0.2 lpm for each of the PID's) created a sampling problem. A modified version was then tried in which the two PID's were linked together by a common probe (see photo, Figure 4). This version was used thereafter.

### 2) Instrument Calibration

Span calibrations were done using mixtures of 1,3-butadiene in air. This chemical was a compromise choice based on availability, range of concentration, and expected response values. The standard had to be stable, and not exceed the detection range of the FID (0-1000 ppm).

### 3) Span and Zero Stability

Span and zero drift observations were made in the laboratory over a several day period before field testing to determine instrumental drift over a several hour continuous use period. Arbitrary gain potentiometer settings were used to maximize each instrument's concentration range. The range of the instruments' responses are summarized in Table 1. A table of all observations is contained in Appendix B. Typically, span drift over a 6-7 hour period was observed to be 7-9 percent downward from the preset maximum, presumably due to slightly diminishing battery strength.

The two PID's were adjusted to high sensitivity settings since small concentrations of fugitive emissions were considered to be of greatest interest. The PID containing the 10.2 eV lamp was adjusted to read 1000 for a 500 ppm butadiene standard; a setting of 1800 for the 900 ppm standard was unattainable. The PID containing the 11.7 eV lamp indicated considerably less sensitivity to the butadiene standard; a setting of 10.0 was used for the 500 ppm standard. The FID was adjusted to read 500 for the 500 ppm standards, and read near 900 for the 900 ppm standard. These span potentiometer settings were not changed during the span stability test period.

TABLE 1

SPAN AND ZERO STABILITY

Instrument Response, ppm of 1,3-butadiene in air

| Date | 10.2 eV PID | | | 11.7 eV PID | | | FID | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0ppm | 500ppm | 900ppm | 0ppm | 500ppm | 900ppm | 0ppm | 500ppm | 900ppm |
| 07/11/83 | 0 | 950±26 | 1246±38 | 0 | 11.1±0.9 | 14.2±0.7 | 0 | 531±27 | 886±44 |
| 07/12/83 | 0 | 949±91 | 1287±69 | 0 | 12.0±1.5 | 15.8±1.5 | 3 | 518±18 | 894±35 |
| 07/13/83 | 0 | 1001±34 | 1336±22 | 0 | 10.8±0.8 | 15.8±1.1 | 1 | 490±35 | 822±75 |
| 07/14/83 | 0 | 991±33 | 1317±20 | 0 | 9.9±0.6 | 14.9±0.3 | 2 | 484±32 | 821±35 |

NOTES: 1) Only one set of values (11.7 eV PID for 7/12/83) exceeds a precision value of ± 10% RDS.

2) In general, observed values tended to decrease with length of usage (diminishing available battery power), and continuous usage over a period of several days may be beyond normally expected usage. On 7/13/83, for example, the battery pack on the FID indicated low at 1430 hours. On 7/14/83, the battery was recharged for a short period after overnight recharge followed by approximately 3 hours continuous operation.

3) Appendix B lists all observed values.

The detectors were operated approximately seven hours per day for four days, with overnight battery recharging. One PID required servicing during this time to repair an intermittent short.

4) Field Testing

The two PID's were tested, and compared to the FID response, in a limited field study conducted at the Cincinnati Municipal Sewer District's Liquid Waste Incinerator during July 25-29, 1983. Sampling was done by 1) placing the two probes (one for both PID's and one for the FID) within 1-2 cm of a surface, 2) reading indicated maxima or swing (if observed) and 3) moving the probes away until readings were at ambient levels (which varied somewhat depending on location). This sequence was normally repeated one to three times, and the data recorded. An initial survey was made of all incinerator operations from truck off-loading through storage, mixing, and transfer to the incinerator feed nozzles. Post-combustion ash was also sampled for fugitive emissions. Since the incinerator had been out of operation for some time prior to this field testing period, the majority of tanks in the tank farm were empty. These tanks and their associated pumps and valves were found not to be sources of fugitive emissions at this time, and were therefore not included as sites for routine sampling.

Eight sites were selected for periodic sampling. These were:

A: A pump in the pumphouse used to pump waste from off-loading trucks into a storage tank,

B: The head space over an open 5 gallon pail used to collect drippings from the coupling between off-loading trucks and the hose connected to the pump inlet fitting,

C: The open ports on top of each off-loading truck,

D: The end of the hose disconnected after off-loading a truck,

E: A vent on the top of a tank being filled with liquid waste,

F: An open porthole approximately three feet above ground level on a tank filled to the bottom of the port with water and residual liquid waste,

G: Several clogged in-line pump filters removed from service,

H: The pump on the tank blending the incinerator feed.

A total of 91 comparisons of all three detectors were made at these 8 sites. Of these, 87 sets were replicates of 2 or more independent readings (for 96% completeness). The raw data for all sites sampled are listed in Appendix C.

For a number of the measurements, relatively large excursions of up to 500 ppm (due to wind gusting and changing direction) were observed. Many

readings on the FID exceeded the scale maximum of "1000". These data points are probably not in excess of 2000 ppm, based on simultaneous PID readings. Attempts to use recorders on the instruments were abandoned due to the slowness of the recorder response time.

The average response for each set of data observed for each PID and the FID, and the response of each PID data set relative to the FID response are listed in Tables 2A through 2H.

All response data was examined for outliers. Six points (each from sets of three or more values) were determined to be outliers at the 90% confidence level by testing, and were excluded from data averaging. These data are identified in Tables C-1 through C-8.

Calibration checks of the three detectors were made three times daily during the field test period. A 900 ppm 1,3-butadiene in air standard (prepared by Scott Specialty Gases) was used to check instrument operation. One adjustment (to change the reading from 14 to 20 for the 900 ppm span gas) and one malfunction correction (10.2 eV PID) were made to the instruments during the test period. Field calibration checks are listed in Table 3. Coefficients of variation (CV) of averaged field calibration checks were in all cases higher than laboratory calibration checks. Laboratory CV's for the 10.2 eV PID ranged from 1.5 to 5.4%, whereas field CV's ranged from 8.6 to 15.8%. Laboratory CV's for the 11.7 eV PID ranged from 2.0 to 9.5%, and field CV's ranged from 6.2 to 24.7%.

The nature of the wastes delivered to the incinerator for subsequent combustion during the field study period was such that the response observed on the unit containing the 10.2 eV light source greatly exceeded that from the unit containing the 11.7 eV light source. Typically the waste delivered during the field period contained 11% chlorine. Different wastes were blended to attain a given BTU content before incinerating. The photographs shown in Figures 1 - 7 illustrate routine incinerator operation and prime sources of fugitive emissions observed.

## IV. Conclusions and Recommendations

The response observed using the 10.2 eV PID was far greater than the response observed using the 11.7 eV PID. The variety of response observed also indicates the wide variety of wastes delivered for incineration.

The 11.7 eV lamp is reported to have low photoionization sensitivity for many of the compounds for which the 10.2 eV lamp has considerable utility. The calibration standard used is among these, as evidenced by the low maximum setting of 20 for the 900 ppm concentration mixture of 1,3-butadiene in air. The wastes delivered to the incinerator during the test period were evidently not of any type for which the 11.7 eV lamp has even moderate sensitivity.

The 10.2 eV PID is recommended over the 11.7 eV PID for walkthrough surveys in liquid waste incinerators of this type. The FID (such as the

TABLE 2A

Site A - Pump in Pumphouse

Average Observed Response (AR), and Relative Response Ratios (RR), FID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | 0917 | 350 | 0.89 | 5 | 0.01 | 395 |
| | 1330 | 560 | 1.3 | 6 | 0.01 | 430 |
| | 1430 | 410 | 2.3 | 3 | 0.02 | 180 |
| 7/27 | 1225 | 20 | 1.0 | 1 | 0.05 | 20 |
| 7/28 | 1134 | 850 | ∿0.85 | 18 | 0.02 | 1000+ |
| | 1304 | 500 | ∿0.50 | 8 | 0.01 | 1000+ |

NOTE: The average observed response (AR) for the FID was assumed to be 1000 ppm (as butadiene) in all cases where average readings exceeded 1000 ppm maximum scale reading.

TABLE 2B

Site B - Headspace over Five Gallon Pail

Average Observed Response (AR), and Relative Response Ratios (RR),
FID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | 0926 | 150 | 0.60 | 3 | 0.01 | 250 |
| | 1430 | 650 | ∿0.65 | 6 | ∿0.01 | 1000+ |
| | 1641 | 200 | 1.0 | 3 | 0.01 | 200 |
| 7/27 | 1021 | 650 | ∿0.65 | 11 | ∿0.01 | 1000+ |
| | 1122 | 45 | 1.0 | 1 | 0.02 | 45 |
| | 1247 | 900 | ∿0.90 | 9 | ∿0.01 | 1000+ |
| 7/28 | 0755 | 700 | ∿0.70 | 18 | ∿0.02 | 1000+ |
| | 0844 | 700 | ∿0.70 | 20 | ∿0.02 | 1000+ |
| | 0945 | 600 | ∿0.60 | 13 | ∿0.01 | 1000+ |
| | 1035 | 650 | ∿0.65 | 12 | ∿0.01 | 1000+ |
| | 1132 | 600 | 0.63 | 11 | ∿0.01 | 950 |
| | 1304 | 800 | 0.80 | 16 | ∿0.02 | 1000+ |
| | 1350 | 900 | ∿0.90 | 16 | ∿0.02 | 1000+ |
| | 1444 | 1000 | ∿1.0 | 21 | ∿0.02 | 1000+ |
| | 1553 | 700 | 0.88 | 12 | 0.02 | 800 |

TABLE 2C

Site C - Ports on Off-loading Trucks

Average Observed Response (AR), and Relative Response Ratios (RR),
FID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | 0926 | 400 | ∿0.40 | 5 | ∿0.01 | 1000+ |
| | 1330 | 1650 | ∿1.7 | 15 | ∿0.01 | 1000+ |
| 7/27 | 1234 | 900 | ∿0.9 | 16 | ∿0.02 | 1000+ |
| | 1341 | 1700 | ∿1.7 | 20 | ∿0.02 | 1000+ |
| 7/28 | 1127 | 1000 | ∿1.0 | 23 | ∿0.02 | 1000+ |

TABLE 2D

Site D - Disconnected Hose

Average Observed Response (AR), and Relative Response Ratios (RR),
FID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | 1116 | 750 | ∿0.75 | 14 | ∿0.01 | 1000+ |
| | 1330 | 850 | ∿0.85 | 10 | ∿0.01 | 1000+ |
| | 1445 | 350 | ∿0.35 | 8 | ∿0.01 | 1000+ |
| | 1641 | 450 | 0.50 | 6 | ∿0.01 | 900 |
| 7/27 | 1020 | 40 | 1.3 | 1 | 0.03 | 30 |
| | 1122 | 900 | ∿0.90 | 16 | ∿0.02 | 1000+ |
| 7/28 | 0745 | 800 | ∿0.80 | 26 | ∿0.03 | 1000+ |
| | 0842 | 450 | ∿0.45 | 13 | ∿0.01 | 1000+ |
| | 1033 | 450 | ∿0.45 | 10 | ∿0.01 | 1000+ |
| | 1315 | 550 | 0.69 | 6 | ∿0.01 | 800 |
| | 1444 | 650 | ∿0.65 | 10 | ∿0.01 | 1000+ |

TABLE 2E

Site E - Tank Vent

Average Observed Response (AR), and Relative Response Ratios (RR),
FID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | 1015 | 500 | ∿0.50 | 8 | ∿0.01 | 1000+ |
| | 1440 | 500 | ∿0.50 | 9 | ∿0.01 | 1000+ |
| 7/27 | 1035 | 800 | ∿0.80 | 15 | ∿0.02 | 1000+ |
| | 1128 | 800 | ∿0.80 | 15 | ∿0.02 | 1000+ |
| | 1255 | 800 | ∿0.80 | 15 | ∿0.02 | 1000+ |
| | 1431 | 800 | ∿0.80 | 14 | ∿0.01 | 1000+ |
| 7/28 | 0824 | 800 | ∿0.80 | 16 | ∿0.02 | 1000+ |
| | 0854 | 850 | 0.92 | 23 | 0.02 | 920 |
| | 0957 | 1000 | ∿1.0 | 24 | ∿0.02 | 1000+ |
| | 1045 | 450 | ∿0.45 | 10 | ∿0.01 | 1000+ |
| | 1139 | 700 | ∿0.70 | 19 | ∿0.02 | 1000+ |
| | 1322 | 800 | ∿0.80 | 17 | ∿0.02 | 1000+ |
| | 1403 | 900 | ∿0.90 | 20 | ∿0.02 | 1000+ |
| | 1458 | 900 | ∿0.90 | 19 | ∿0.02 | 1000+ |
| | 1536 | 900 | ∿0.90 | 17 | ∿0.02 | 1000+ |

TABLE 2F

Site F - Open Porthole, Empty Tank

Average Observed Response (AR), and Relative Response Ratios (RR),
FID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | 0808 | 15 | 0.60 | 0.4 | 0.02 | 25 |
| | 1227 | 30 | 0.43 | 1 | 0.01 | 70 |
| | 1653 | 35 | 0.88 | - | | 40 |
| 7/27 | 1030 | 55 | 0.69 | 2 | 0.03 | 80 |
| | 1136 | 40 | 0.62 | 1 | 0.02 | 65 |
| | 1300 | 75 | 0.56 | 2 | 0.01 | 135 |
| | 1420 | 60 | 0.55 | 2 | 0.02 | 110 |
| | 1537 | 60 | 0.75 | 1 | 0.01 | 80 |
| | 1616 | 50 | 0.77 | 1 | 0.02 | 65 |
| 7/28 | 0810 | 65 | 0.50 | 5 | 0.04 | 130 |
| | 0851 | 120 | 0.67 | 5 | 0.03 | 180 |
| | 0952 | 120 | 0.71 | 5 | 0.03 | 170 |
| | 1040 | 130 | 0.68 | 3 | 0.02 | 190 |
| | 1139 | 160 | 0.73 | 4 | 0.02 | 220 |
| | 1314 | 115 | 0.58 | 3 | 0.02 | 200 |
| | 1358 | 90 | 0.64 | 2 | 0.01 | 140 |
| | 1451 | 140 | 0.70 | 4 | 0.02 | 200 |
| | ~1530 | 130 | 0.68 | 3 | 0.02 | 190 |
| | 1558 | 170 | 0.68 | 4 | 0.02 | 250 |

TABLE 2G

Site G - Clogged Pump Filters

Average Observed Response (AR), and Relative Response Ratios (RR),
FID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | 0900 | 180 | 0.72 | 3 | 0.01 | 250 |
| 7/27 | 1143 | 150 | 1.0 | 2 | 0.01 | 150 |
| | 1306 | 180 | 1.4 | 2 | 0.01 | 130 |
| | 1428 | 190 | 1.1 | 3 | 0.02 | 170 |
| | 1530 | 120 | 1.1 | 2 | 0.02 | 110 |
| | 1600 | 195 | 1.2 | 3 | 0.02 | 160 |
| 7/28 | 0820 | 400 | ∿0.40 | 13 | ∿0.01 | 1000+ |
| | 0847 | 770 | ∿0.77 | 17 | ∿0.02 | 1000+ |
| | 0945 | 330 | 1.1 | 6 | 0.02 | 290 |
| | 1037 | 370 | 0.86 | 7 | 0.02 | 430 |
| | 1134 | 220 | 1.2 | 4 | 0.02 | 190 |
| | 1310 | 210 | 0.95 | 3 | 0.01 | 220 |
| | 1354 | 160 | 1.2 | 3 | 0.02 | 130 |
| | 1449 | 155 | 1.1 | 3 | 0.02 | 140 |
| | 1555 | 160 | 0.94 | 4 | 0.02 | 170 |

TABLE 2H

Site H - Mixing Tank Pump

Average Observed Response (AR), and Relative Response Ratios (RR),
RID Response = 1

| Date | Time | 10.2 eV PID | | 11.7 eV PID | | FID |
|---|---|---|---|---|---|---|
| | | AR | RR | AR | RR | AR |
| 7/26 | | 133 | 0.78 | 3 | 0.02 | 170 |
| | 1705 | 120 | 0.92 | 2 | 0.02 | 130 |
| 7/27 | 1136 | 270 | 0.87 | 5 | 0.02 | 310 |
| | 1300 | 250 | 0.96 | 3 | 0.01 | 260 |
| | 1426 | 200 | 0.93 | 3 | 0.01 | 215 |
| | 1530 | 60 | 1.2 | 1 | 0.02 | 50 |
| | 1613 | 110 | 0.73 | 1 | 0.01 | 150 |

TABLE 3

Field Calibration Checks

| Date | Time | Instrument Response, ppm 10.2 eV PID | 11.7 eV PID | FID |
|---|---|---|---|---|
| 7/25/83 | 1530 | 1470 | 14.7 | 970 |
| 7/26/83 | 0730 | 1360 | 14.8 | 1020 |
| | 1236 | 1180 | 12.7 | 890 |
| | 1720 | 1170 | 11.7 | 770 |
| 7/27/83 | 0730 | 1200 | 20.0* | 1000 |
| | 1150 | 1490 | 19.2 | 850 |
| | 1633 | 1330 | 17.7 | 700 |
| 7/28/83 | 0730 | 1300 | 20.0 | 1000 |
| | 1205 | 1090 | 18.8 | 873 |
| | | 1500 | 29.0† | 770 |

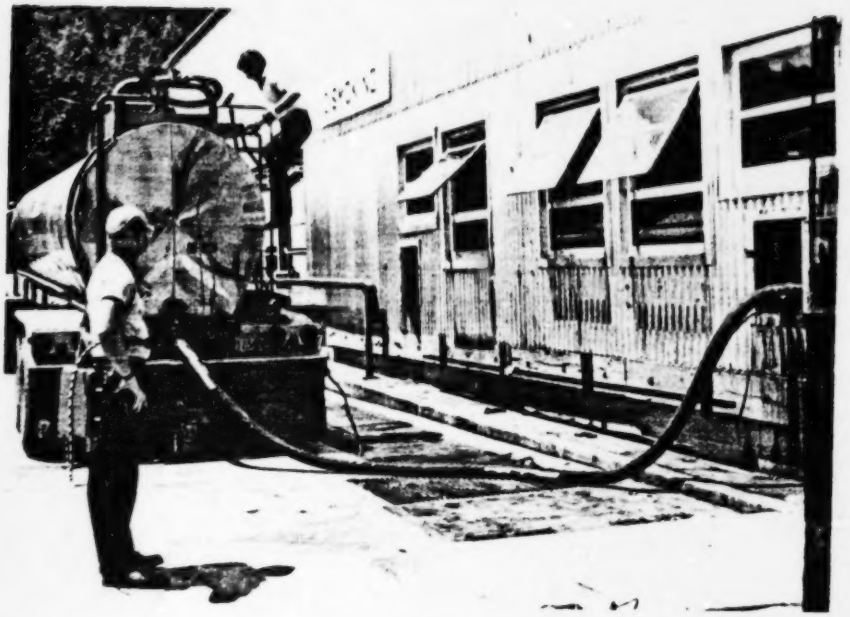
NOTES: 1) Span settings were left unchanged from lab stability study with the exception of 11.7 eV PID adjustment on 7/27/83.

2) Cal gas used (900 ppm 1,3-butadiene) was from same lot used in laboratory study.

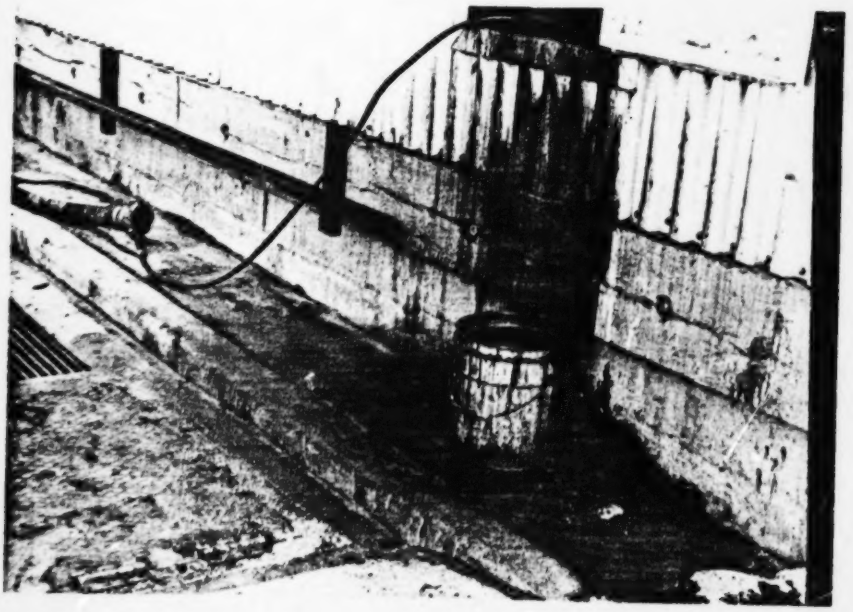
3) Observed concentrations decrease as a function of use time (battery voltage depletion).

* Span potentiometer adjusted to increase readout from 15.0 to 20.0 on 20 ppm scale.

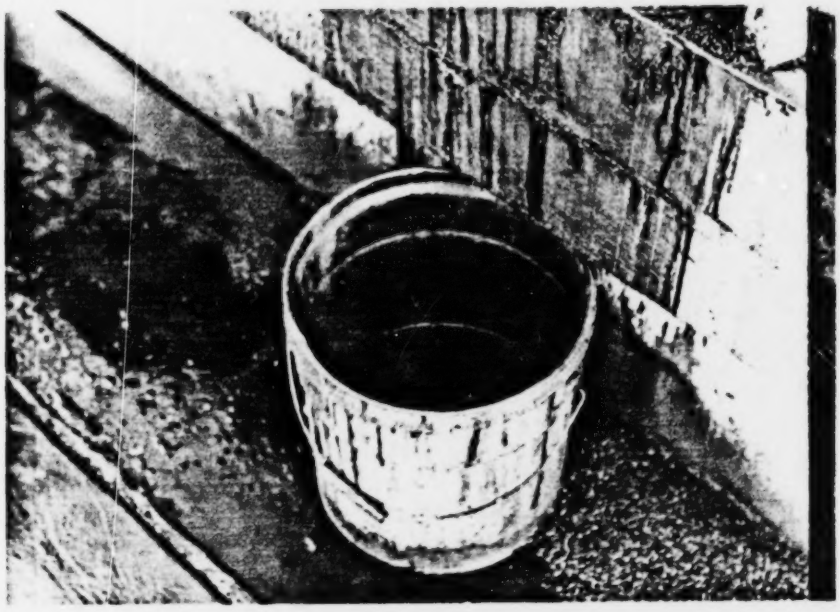
† Suspect data set.



Tank truck off-loading
FIGURE 1

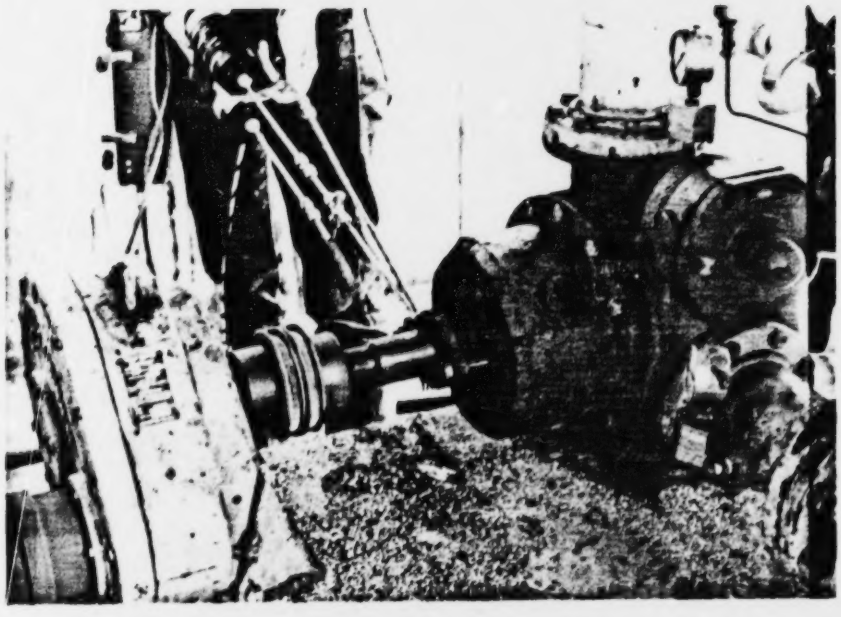


5 Gallon pail and hose from tank truck
FIGURE 2



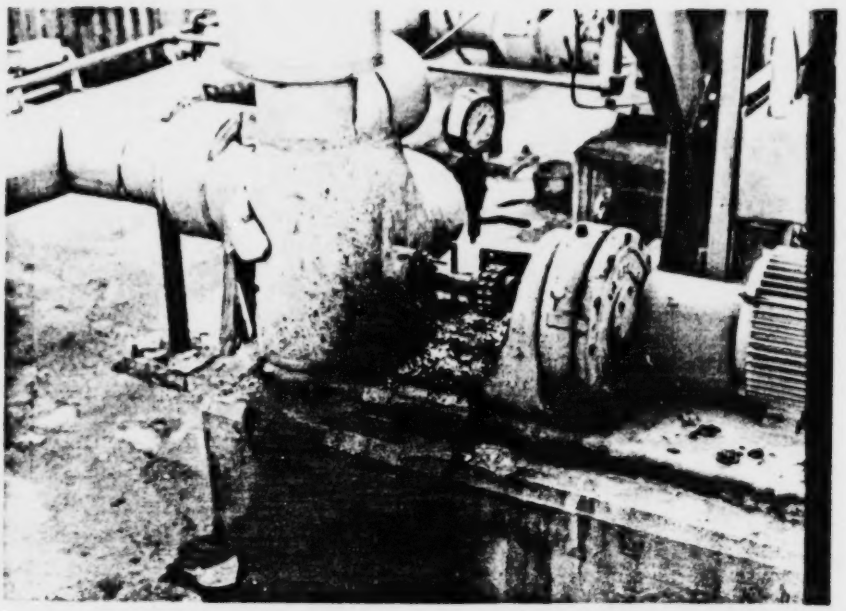
5 Gallon Pail

FIGURE 3



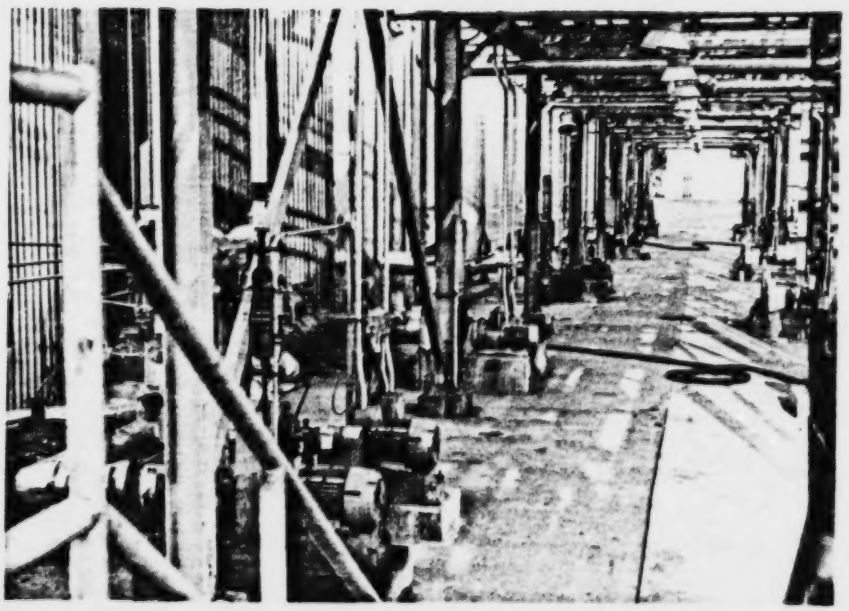
Simultaneous sampling at pump packing gland

FIGURE 4



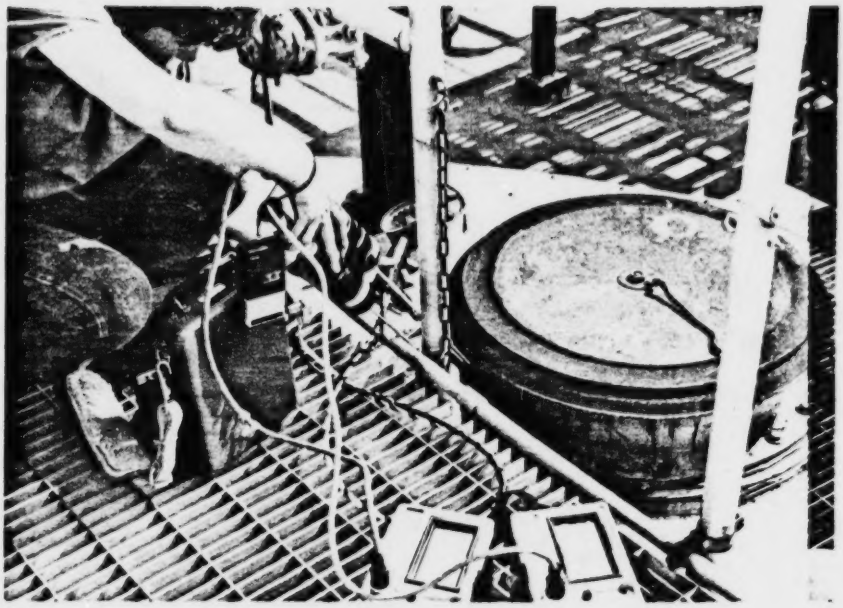
Another pump in pumphouse

FIGURE 5



Tank Farm

FIGURE 6



Vent on top of storage tank

FIGURE 7

OVA-128 used as the reference instrument in this study) is also quite suitable. It must be remembered, however, that the wide variety of both waste type and composition made quantification of the response data virtually impossible, and that no one portable survey instrument should be considered as "best" for this application.

## APPENDIX A

INTERIM REPORT: Methodology Evaluation and Recommendations for Field Evaluation of Two Instruments

# FUGITIVE ORGANIC EMISSIONS FROM HAZARDOUS WASTE INCINERATORS

## INTERIM REPORT:

Methodology Evaluation
and
Recommendations for Field Evaluation of Two Instruments

85275-14

February 1983

## I. ABSTRACT

The current methodology for portable volatile organic compound monitors has been evaluated. Methodologies are summarized and tabulated. A conclusion has been reached, and recommendations are made for a limited field study comparison of two monitors utilizing photoionization detection (at different excitation voltages), versus a flame ionization detector.

## II. INTRODUCTION

We have evaluated the current methodology for portable volatile organic compound (VOC) monitors with regard to their applicability in monitoring fugitive organic emissions from hazardous waste incinerators. The evaluation included data taken from manufacturer's literature (Appendix A), personal communications (Appendix B), and published reports and literature (Appendix C).

## III. APPROACH

The necessary characteristics considered for the instruments included:

- Portability versus transportability
  The instrument must be truly transportable by one person, be battery-powered, and be self-contained.

- Readout
  Direct, immediate readout is necessary.

- Operation Simplicity

- Interferences
  Gases such as $O_2$, $N_2$, $CO_2$, HCl should not interfere.
  Water vapor should not interfere.

- Range
  As wide as possible.

- Lower Detection Limit
  Must have sufficient sensitivity to detect 100 ppm or less of fugitive emissions when held within a reasonable distance[1] from surfaces.

1 For a walkthrough survey, a reasonable distance may be defined as approximately 10 centimeters from the surface.

Table A-1 lists a number of types of portable monitors potentially suitable for use on this task.[2] From the data in Table A-1 and elsewhere in this report, the photoionization detectors appear to have considerable potential. Other types of instruments tend to suffer from one or more of the following:

- slow response time
- unsuitability for use on halogenated hydrocarbons
- designed for single analyte usage.
- lack of portability
- interferences

## IV. AVAILABLE TECHNIQUES

- Infrared Detection Devices

Three such monitors were considered, all from a single manufacturer. The monitor stated to be lowest in price is designed for use on a single gas or vapor only, thus limiting use. A second model, higher in price, is also designed for single gas use, but can accomodate a variety of gases through use of filters and different scale direct readouts. A third model, also higher in price does not have direct readout in concentration units, but instead reads in absorbance units, or percent transmittance. The last two mentioned are not truly portable since their weight is between 20 and 30 pounds.

- Catalytic Combustion Devices

These instruments are based on combusting the sample by exposing it to a catalytic surface, and monitoring the heat evolved. Such instruments, although low in weight and cost, are reported to have a memory effect which lasts for some period of time if inadvertently exposed to high concentrations of gas or vapor. A large amount of data on response factors has been generated for this type of monitor.

- Thermal Conductivity Devices

These monitors are also low in cost and readily portable, but response can be easily influenced by the amount of water vapor in the sample, which would interfere to varying extents with results.

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[2] Majority of information obtained from instrument manufacturers' literature.

TABLE A-1

Portable Fugitive Emissions Monitors*

| Type | Cost | weight, pounds | range, ppm | % accuracy | % precision | response, % | sensitivity | ease of operation |
|---|---|---|---|---|---|---|---|---|
| FID | ∿3000-5000 | <20 | 0-10,000 | ±2-5 | ±2-5 | 2-5 | ∿1 ppm | simple |
| IR | ∿ 6500 | <25 | variable | ±5 | variable | ∿15 selectable | ∿1 ppm | simple |
| IR | ∿ 9000 | <25 | variable | variable | not stated | 1 to 40 | not stated | simple |
| Catalytic Combustion | ∿1000 | <10 | up to 100% of gas conc. | ±3 | ±3 | 10 | not stated | simple |
| Thermal Conductivity | <1000 | <10 | up to 100% of gas conc. | ±3 | ±3 | not stated | ∿2 ppm | simple |
| PID | ∿4000 | <15 | 0-2000 | ±2 | not stated | 5 | ∿1 ppm | simple |

* Some information extracted from "Summary of Available Portable VOC Detection Instruments," by M. Y. Anastas and H. J. Belknap, EPA-340/1-80-010

- Flame Ionization Detection Devices (FID's)

Instruments utilizing FID's are readily portable, direct reading, relatively simple to maintain, and not expensive. They are also linear (to a given species) over a wide dynamic range of concentration. However, FID response varies greatly among different compound types (i.e. response factors extimated at 10,000 ppmV for acetone (0.80), carbon tetrachloride (>100.0) and cyclohexane (0.47)) (1). Ambient water vapor and oxygen content are large FID interferences by influencing the ionization of compounds. A considerable relative response data base is available for FID's. (1)

- Photoionization Detection (PID) Devices

PID's are sensitive only to compounds with ionization potentials up to 0.2-0.3 eV above that of the source lamp. Three lamp voltages are available, which can be used in speciation discrimination. PID's are light in weight, relatively low in cost, and have good response time.

The linearity of response is not good, however, and requires standardizing with several span gases over the 0-2000 ppm range. PID's have been used in ambient applications, and are reported not to be affected by water vapor or oxygen content (in one transportable non-survey GC/PID instrument air is the preferred carrier gas).

## V. Conclusion and Recommendations

The main conclusion is that no one given type of monitor is "best" for all applications. We recommend that two photoionization detectors (differing in photoexcitation voltage) be field tested (on a limited basis) against a flame ionization detector, for which a large number of response factors have previously been determined. (2)

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(1) "Response Factors of VOC Analyzers at a Meter Reading of 10,000 PPMV for Selected Organic Chemicals," D.A. DuBose, DCN 80-203-001-01-48, Interim Report for EPA/IERL, RTP by Radian Corp.

(2) "Response of Portable VOC (Volatile Organic Compounds) Analyzers to Chemical Mixtures," Radian Corporation, June 1981 PB 81-234262

## APPENDIX A (1)

Manufacturer's Literature

MANUFACTURER'S LITERATURE

- Foxboro Analytical, A Division of the Foxboro Company
  Century Systems Portable Organic Vapor Analyzer Model OVA-128
  MIRAN Portable Ambient Air Analyzers: MIRAN-103 and MIRAN-104

- Bacharach Instrument Company
  Model TLV Sniffer

- HNU Systems, Inc.
  Model PI 101 Photoionization Analyzer

## APPENDIX A (2)

Personal Communications

PERSONAL COMMUNICATIONS

- Winton Kelly and K. C. Hustvedt
  Emission Measurement Branch
  Emission Standards and Engineering Division
  EPA, Research Triangle Park, NC

- Thomas Spittler
  Director, New England Regional Laboratory
  Surveillance and Analysis Division
  EPA, Lexington, MA

- Franklin Papp
  New Jersey Department of Environmental Protection

- Patrick J. Ford
  GCA Corporation, Technology Division

- Graham E. Harris
  Radian Corporation

- Thomas Giessler
  James Cudahy
  'Dike' Erikson
  IT Corporation

- David Moore
  TRW

- Jeffrey W. Adams
  Kenneth T. Menzies
  Arthur D. Little, Inc.

## APPENDIX A (3)

Published Literature Survey

PUBLISHED LITERATURE SURVEY

"Response Factors of VOC Analyzers at a Meter Reading of 10,000 PPMV for Selected Organic Chemicals"
Draft Technical Note by D. A. DuBose, Radian Corporation for Chemical Processes Branch, EPA/IERL, RTP 15 Dec. 1980.

"Response of Portable VOC Analyzers to Chemical Mixtures"
Final Report By D. A. DuBose, G. E. Brown, and G. E. Harris, Radian Corporation for Chemical Processes Branch, EPA/IERL, RTP June 1981 PB 81-234262

"Measurement of Volatile Organic Compounds"
by Emission Measurement Branch for DAA for Air Quality Planning and Standards Office of Air, Noise, and Radiation, EPA/IERL, RTP September 1979 PB 80-221674

EPA/R&D Bulletin August 1980
Industrial Pollution Control

"Source Emission Measurements of Volatile Organic Chemicals"
by G. W. Scheil, F. J. Bergman and H. Owens, Midwest Research Institute for Stationary Source Emission Research Branch, EPA/ESRL, RTP July 1980 PB 80-198518

Proposed Method 21 "Determination of Volatile Organic Compound Leaks" Federal Register, Vol. 46, No. 2, Monday, Jan. 5, 1981.

Method 25 "Determination of Total Gaseous Nonmethane Organic Emissions as Carbon
40 CFR Part 60 Appendix A

Proposed Method 25A "Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer" Federal Register, Vol. 45, No. 244, Wednesday, December 17, 1980.

Proposed Method 25B "Determination of Total Gaseous Organic Concentration Using a Nondispersive Infrared Detector" Federal Register, Vol. 45, No. 244, Wednesday, December 17, 1980.

Proposed Method 23 "Determination of Halogenated Organics from Stationary Sources" Federal Register 45, #114, Wednesday, June 11, 1980.

"Summary of Available Portable VOC Detection Instruments"
EPA-340/1-80-010 March 1980, M. Y. Anastas and H. J. Belknap Pedco Environmental

PUBLISHED LITERATURE SURVEY (continued)

"Evaluation of the Walkthrough Survey Method for Detection of Volatile Organic Compound Leaks"
by R. C. Weber and K. Mims, Industrial Pollution Control Division, EPA/IERL, Cincinnati April 1981 PB 81-199382

"Controlling Fugitive Emissions"
M. J. Wallace Chem. Eng. August 27, 1979.

"Measuring Fugitive Emissions from Petrochemical Plants"
T. W. Hughes, D. R. Tierney, and Z. S. Zhan Chem. Eng. Progress August 1979.

"Development of Measurement Techniques for Fugitive Emissions from Process and Effluent Streams"
by H. J. Kolnsberg, TRC for Office of Energy, Minerals, and Industry, EPA/IERL, TRP May 1979 EPA-600/7-79-116

"Ambient Air Non-Methane Hydrocarbon Monitor"
by D. E. Burch, Ford Aerospace and Communications Corporation for Atmospheric Chemistry and Physics Division, EPA/ESRL, RTP December 1980 PB 81-120008

"Photoionization Detector Sensitivity of Organic Compounds"
by M. L. Langhorst, Dow Chemical Company, J. Chrom. Sci. 19, February 1981.

"Instrumentation for "On Site" Survey and Identification of Hazardous Waste"
by J. N. Driscoll and G. F. Hewitt, HNU Systems, Inc. Ind. Hyg. News, 5, No. 3, May 1982.

# APPENDIX B

## Span and Zero Stability Observations

## Span and Zero Stability

### Conc. in ppm 1,3-butadiene in air

| Date | Time | 10.2 eV PID | | | 11.7 eV PID | | | OVA-128 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0ppm | 500ppm | 900ppm | 0ppm | 500ppm | 900ppm | 0ppm | 500ppm | 900ppm |
| 7/11/83 | 1000 | -0.4 | 950 | 1297 | 0 | 11.0 | 14.9 | 1* | 610 | 897 |
| | 1046 | 0 | 937 | 1273 | 0.1 | 10.0 | 14.9 | 1 | 577 | 973 |
| | 1115 | 0 | 980 | 1293 | 0 | 11.4 | 15.0 | 1 | 550 | 883 |
| | 1145 | 0 | 980 | 1277 | 0 | 11.8 | 14.8 | 1 | 517 | 893 |
| | 1210 | 0 | 977 | 1277 | 0 | 11.6 | 14.7 | 1 | 537 | 890 |
| | 1310 | 0 | 947 | 1220 | 0 | 10.6 | 12.9 | 1 | 493 | 863 |
| | 1400 | 0 | 973 | 1247 | 0 | 10.0 | 13.5 | 1 | 510 | 810 |
| | 1430 | 0 | 947 | 1223 | 0 | 10.5 | 14.2 | 1 | 530 | 933 |
| | 1515 | 0 | 940 | 1197 | 0 | 13.1 | 14.0 | - | 567 | 907 |
| | 1535 | 0 | 903 | 1200 | 0 | 11.2 | 14.0 | - | 517 | 840 |
| | 1635 | 0 | 913 | 1207 | 0 | 10.8 | 13.9 | - | 510 | 860 |
| 7/12/83 | 0800 | 0 | 1050 | 1360 | 0 | 13.7 | 18.1 | 1 | 490 | 860 |
| | 0845 | 0 | 1037 | 1383 | 0 | 12.5 | 17.3 | 3.2 | 527 | 877 |
| | 0915 | 0 | 1027 | 1333 | 0 | 12.1 | 16.5 | 3 | 510 | 897 |
| | 1015 | 0 | 940 | 1297 | 0 | 11.4 | 16.8 | 3 | 503 | 857 |
| | 1100 | 0 | - | - | 0 | 11.4 | 14.1 | - | 527 | 850 |
| | 1130 | 0 | 830 | 1257 | 0 | 13.8 | 13.5 | 3 | 527 | 910 |
| | 1315 | 0 | 923 | 1220 | 0 | 13.6 | 15.8 | 3 | 503 | 927 |
| | 1415 | 0 | 840 | 1187 | 0 | 9.9 | 15.3 | 3 | 530 | 920 |
| | 1515 | | - | - | 0 | 9.9 | 15.1 | 3 | 547 | 947 |
| | | 10.2eV unit shorting | | | | | | | | |
| 7/13/83 | 0930 | 10.2 eV PID removed from | | | 0 | 11.3 | 16.9 | 1 | 537 | 970 |
| | 1000 | | | | 0 | 11.4 | 17.7 | 1 | 520 | 860 |
| | 1030 | | | | 0 | 11.0 | 17.7 | 1 | 507 | 817 |
| | 1100 | service | | | 0 | 10.7 | 14.7 | 1 | 507 | 813 |
| | 1130 | | | | 0 | 11.4 | 15.7 | 1 | 517 | 920 |
| | 1300 | for repairs | | | 0 | 11.0 | 15.5 | 1 | 500 | 833 |
| | 1330 | | | | 0 | 11.0 | 15.3 | 1 | 500 | 817 |

* pre-set to read 1 at 0

Span and Zero Stability (continued)

| Date | Time | 10.2 eV PID | | | 11.7 eV PID | | | OVA-128 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0ppm | 500ppm | 900ppm | 0ppm | 500ppm | 900ppm | 0ppm | 500ppm | 900ppm |
| 7/13/83 | 1430 | 0 | 997 | 1337 | 0 | 10.1 | 15.0 | 1 | 453 | 810 |
| | 1530 | 0 | 970 | 1313 | 0 | 8.8 | 14.8 | 1 | 480 | 727† |
| | 1600 | 0 | 1037 | 1357 | 0 | 11.5 | 15.4 | - | 433 | 737 |
| | 1640 | | | | 0 | 10.8 | 14.8 | 1 | 437 | 740 |
| 7/14/83 | 0930 | 0 | 1027 | 1347 | 0 | 11.0 | 15.5 | 1 | 520 | 857 |
| | 1015 | 0 | 1030 | 1343 | 0 | 10.4 | 14.9 | 1 | 503 | 830 |
| | 1100 | 0 | 927 | 1317 | 0 | 9.3 | 14.6 | 1 | 513 | 813 |
| | 1130 | 0 | 1000 | 1320 | 0 | 9.8 | 14.6 | 1 | 447 | 770←FID turned off |
| | 1330 | 0 | 1000 | 1310 | 0 | 10.3 | 14.5 | 4 | 480 | 853 batt. recharged |
| | 1400 | 0 | 987 | 1293 | 0 | 9.7 | 15.1 | - | 440 | 830 |
| | 1530 | 0 | 967 | 1303 | 0 | 9.4 | 14.8 | - | 457 | 770 |
| | 1630 | 0 | 987 | 1300 | 0 | 9.6 | 14.9 | - | 510 | 847 |

† battery operating out of 'OK' range

# APPENDIX C

## Observed Responses, Three Detectors, Sites A through H

TABLE C-1

Site A - Pump in Pumphouse, Waste Moving from the Truck to a Storage Tank

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| 07/26 | 0917 | 30† | 2† | 30-40† |
| | | 200+ | 4 | 260-420 |
| | | 500 | 6 | 400-500 |
| | 1330 | 500† | 4 | 100-300 |
| | | 1400† | 11 | 800-1000† |
| | | 800 | 6 | 600-1000+ |
| | | 500 | 4 | 300-800 |
| | | 500 | 4 | 300 |
| | | 500 | 4 | 300 |
| | 1430 | 800 | 2 | 100-200 |
| | | 200 | 4 | 150-250 |
| | | 100-150 | 3 | 200-400 |
| | | 500 | 2 | 50-100 |
| 07/27 | 1225 | 20 | 1 | 20 |
| 07/28 | 1134 | 600-700 | 11-12 | 1000+ |
| | | 900-1000 | 20+ | 1000+ |
| | | 900-1000 | 20-25 | 1000+ |
| | 1304 | 300-700 | 5-10 | 1000+ |

†values are outliers, and can be discarded with >0.90 confidence

TABLE C-2

Site B - Headspace Over Drippings in Bucket

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| 07/26 | 0926 | 100-200 | 3 | 200-300 |
| | 1430 | 650 | 7 | 1000+ |
| | | 700 | 7 | |
| | | 650 | 6 | |
| | | 650 | 6 | |
| | | 600 | 5 | |
| | 1641 | 200 | 3 | 100-200 |
| | | 200 | 3 | 200-300 |
| | | 200 | 3 | 180-240 |
| 07/27 | 0750 | -* | - | 20-30 |
| | | - | - | 24 |
| | | - | - | 24 |
| | 0919 | -* | - | 40 |
| | | - | - | 36 |
| | | - | - | 24 |
| | 1021 | 400-500 | 8-11 | 1000+ |
| | | 600-800 | 10-11 | 1000+ |
| | | 700-800 | 12 | 1000+ |
| | 1122 | 40 | 1 | 40 |
| | | 50 | 1-2 | 50 |
| | | 50 | 1-2 | 50 |
| | 1247 | 900 | 10 | 1000+ |
| | | 900 | 9 | 1000+ |
| | | 700 | 8 | 1000+ |
| 07/28 | 0755 | 500-900 | 20 | 1000+ |
| | | 600-900 | 20+ | 1000+ |
| | | 600-700 | 14 | 1000+ |
| | 0844 | 700 | 22 | 1000+ |
| | | 600-700 | 19 | 1000+ |
| | | 600-700 | 19 | 1000+ |
| | 0945 | 500-600 | 13-14 | 1000+ |
| | | 500-600 | 12-13 | 1000+ |
| | | 600-700 | 13 | 1000+ |

*10.2 eV PID malfunction

TABLE C-2 (continued)

Site B - Headspace Over Drippings in Bucket

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| | 1035 | 500-600 | 12 | 1000+ |
| | | 700 | 12 | 1000+ |
| | | 700 | 12 | 1000+ |
| | 1132 | 400-600 | 8-12 | 800-900 |
| | | 600 | 11 | 1000+ |
| | | 600 | 11-12 | 900-1000+ |
| | 1304 | 700-800 | 15-19 | 1000+ |
| | | 900 | 18 | 1000+ |
| | | 800 | 14 | 1000+ |
| | 1350 | 800-1000 | 16-18 | 1000+ |
| | | 900 | 16-18 | 1000+ |
| | | 800 | 15 | 1000+ |
| | 1444 | 1000 | 18 | 1000+ |
| | | 800-1000 | 18-22 | 1000+ |
| | | | 12-18 | 1000+ |
| | 1553 | 500-700 | 10-12 | 500-700 |
| | | 600 | 11 | 500-1000+ |
| | | 800-900 | 12-14 | 600-1000+ |

TABLE C-3

Site C - Open Filling Port, Top of Truck

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| 07/26 | 0926 | 300 | 5-7 | 1000+ |
| | | 400-600 | 5 | 1000+ |
| | 1330 | 1650-1720 | 21 | 1000+ |
| | | 1500-1700 | 12 | - |
| | | 1500-1700 | 12 | - |
| 07/27 | 1234 | 900 | 17 | 1000+ |
| | | 900 | 16 | - |
| | | 800 | 14 | - |
| | 1341 | 1500-1700 | 20-25 | 1000+ |
| | | 1700 | 20 | 1000+ |
| | | 1700 | 18 | 1000+ |
| 07/28 | 1127 | 1000 | 22 | 1000+ |
| | | 1000 | 22 | 1000+ |
| | | 1000 | 25 | 1000+ |

TABLE C-4

Site D - Unconnected Hose, Truck Coupling End

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| 07/26 | 1116 | 700 | 12 | 1000+ |
| | | 800 | 15 | 1000+ |
| | 1330 | 800-900 | 11 | 1000+ |
| | | 800 | 10 | 1000+ |
| | | 850 | 11 | 1000+ |
| | 1420 | - | - | 200 |
| | 1445 | 200+ | 8 | 1000+ |
| | | 350 | 8 | 1000+ |
| | | 350-500 | 8 | 1000+ |
| | 1641 | 400 | 5 | 1000+ |
| | | 400-500 | 5-6 | 600-800 |
| | | 500 | 6 | 1000+ |
| 07/27 | 0810 | -* | -* | 1000+ |
| | | - | - | 1000+ |
| | | - | - | 1000+ |
| | 0925 | -* | -* | 1000+ |
| | | - | - | 1000+ |
| | | - | - | 1000+ |
| | 1021 | 50 | 1-2 | 30 |
| | | 40-50 | 1 | 40-50 |
| | | 30 | 1 | 20 |
| | 1122 | 900 | 17 | 1000+ |
| | | 900 | 15 | 1000+ |
| | | 900 | 15 | 1000+ |
| 07/28 | 0745 | 600-800 | 20-25 | 1000+ |
| | | 600-900 | 25 | 1000+ |
| | | 700-900 | 30 | 1000+ |
| | 0842 | 300-500 | 10-16 | 1000+ |
| | | 300-600 | 10-20 | 1000+ |
| | | 300-500 | 9-11 | 1000+ |
| | 1033 | 400-500 | 10 | 1000+ |
| | | 400-500 | 8-11 | 800-1000+ |
| | | 400-500 | 8-10 | 700-1000+ |

* 10.2 eV PID malfunction

TABLE C-4 (continued)

Site D - Unconnected Hose, Truck Coupling End

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| | 1315 | 500-600 | 5-10 | 800-1000 |
| | | 500 | 5 | 600-800 |
| | 1444 | 600-700 | 8-10 | 1000+ |
| | | 500-800 | 8-12 | 1000+ |
| | | 500-900 | 8-13 | 900-1000+ |

TABLE C-5

Site E - Vent on Top of Tank 315

| Date | Time | Observed Responses | | | |
|---|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID | |
| 07/26 | 1015 | 400-500 | 8 | 1000+ | |
| | | 500-600 | 8-9 | 1000+ | |
| | 1440 | 500 | 9 | 1000+ | |
| | | 500 | 9 | 1000+ | |
| 07/27 | 0822 | -* | -* | 10 | (no activity |
| | | - | - | 10 | at this tank |
| | | | | | at this time) |
| | 0930 | -* | -* | 1000+ | |
| | | - | - | 1000+ | |
| | | - | - | 1000+ | |
| | 1035 | 700 | 15 | 1000+ | |
| | | 800 | 15 | 1000+ | |
| | | 800 | 15 | 1000+ | |
| | 1128 | 800 | 15 | 1000+ | |
| | | 800 | 15 | 1000+ | |
| | | 800 | 14 | 1000+ | |
| | 1255 | 800 | 14 | 1000+ | |
| | | 800 | 16 | 1000+ | |
| | | 800 | 14 | 1000+ | |
| | 1431 | 800 | 15 | 1000+ | Trucks off- |
| | | 600-800 | 13-15 | 1000+ | loading mono- |
| | | 600-800 | 13-15 | 1000+ | meric methyl methacrylate remainder of afternoon, so 315 was not further sampled |
| 07/28 | 0824 | 500-900 | 14 | 1000+ | |
| | | 600-800 | 16 | 1000+ | |
| | | 600-800 | 17 | 1000+ | |
| | 0854 | 400-700 | 8-14 | 500-1000+ | |
| | | 1000 | 30 | 1000+ | |
| | | 1000 | 28 | 1000+ | |

TABLE C-5 (continued)

Site E - Vent on Top of Tank 315

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| | 0957 | 900-1000 | 23 | 900-1000+ |
| | | 900-1000 | 22 | 1000+ |
| | | 1000 | 27 | 1000+ |
| | 1045 | 400-900 | 10-25 | 500-1000+ |
| | | 200-500 | 2-7 | 700-1000+ |
| | | 300-500 | 4-10 | 500-1000+ |
| | 1139 | 300-800 | 15-20 | 1000+ flame going |
| | | 900 | 25 | 1000+ out, has to |
| | | 400-900 | 10-20 | 1000+ be re-lit for each reading |
| | 1322 | 1000+ | 22 | 1000+ very gusty |
| | | 300-900 | 10-20 | 300-1000+ |
| | | 700-1000 | 10-20 | 1000+ |
| | 1403 | 800-1000 | 22 | 1000+ |
| | | 800-1000 | 18-20 | 900-1000+ |
| | | 800-1000 | 18-20 | 1000+ |
| | 1458 | 800-1000 | 17-20 | |
| | | 800-1000 | 17-20 | 1000+ flame continues to go out |
| | | 800-1000 | 17-20 | |
| | 1536 | 900-1000 | 18-20 | 1000+ |
| | | 800-1000 | 10-20 | 1000+ |
| | | 800-1000 | 15-20 | 1000+ |

TABLE C-6

Site F - Porthole in Tank 306 at Ground Level
(Inactive Tank, Open Port, Open Vent on Top)

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| 07/26 | 0808 | 15 | 0.4 | 24 |
| | 1227 | 20-30 | 0.6 | 60-80 |
| | | 28-30 | 0.7 | 60-80 |
| | | 27 | 0.7 | 70-90 |
| | ~1400 | - | - | 65 |
| | | | | 65 |
| | 1653 | 50 | - | 30-50 |
| | | 20 | - | 40 |
| 07/27 | 0830 | -* | - | 42 |
| | | - | - | 48 |
| | | - | - | 48 |
| | 0930 | -* | - | 40 |
| | | - | - | 45 |
| | | - | - | 46 |
| | 1030 | 50 | 2 | 60 |
| | | 70 | 2 | 90 |
| | | 50 | 2 | 60 |
| | 1136 | 40 | 1 | 60-70 |
| | | 40 | 1 | 60-70 |
| | | 40-50 | 2 | 60-70 |
| | 1300 | 40 | 1 | 100 |
| | | 100 | 2 | 200 |
| | | 80 | 2 | 100 |
| | | 80 | 2 | 140 |
| | 1420 | 50-80 | 2 | 130 |
| | | 50-60 | 1-2 | 100 |
| | | 60 | 1-2 | 100 |
| | 1537 | 60-70 | 1.5 | 70-80 |
| | | 50-70 | 1 | 80-100 |
| | | 60 | 1 | 70-90 |

* malfunction in 10.2 eV PID
NOTE: Primarily rainwater up to level of port on side of tank

TABLE C-6 (continued)

Site F - Porthole in Tank 306 at Ground Level
(Inactive Tank, Open Port, Open Vent on Top)

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| | 1616 | 60 | <1 | 60-70 |
| | | 50-60 | 1 | 70-80 |
| | | 45 | 1 | 65 |
| | | 60 | 1 | 80 |
| | | 30 | <1 | 50 |
| 07/28 | 0810 | 70 | 4 | 140 |
| | | 60 | 4 | 120 |
| | | 70 | 6 | 140 |
| | 0857 | 100 | 4 | 150 |
| | | 120 | 5-6 | 150-170 |
| | | 110-150 | 5-6 | 200-240 |
| | 0952 | 115 | 4-5 | 120 |
| | | 80 | 3-4 | 120 |
| | | 170 | 4-5 | 270 |
| | 1040 | 120 | 2-3 | 190 |
| | | 130-140 | 4 | 190 |
| | | 130-140 | 3-4 | 200 |
| | 1139 | 170 | 4 | 260 |
| | | 120 | 3-4 | 200 |
| | | 180 | 3-4 | 210 |
| | 1314 | 110 | 3-4 | 200 |
| | | 115 | 3 | 200 |
| | | 120-130 | 3 | 200 |
| | 1358 | 95 | 2-3 | 150 |
| | | 130 | 3 | 200 |
| | | 70 | 2 | 110 |
| | | 65 | 2 | 100 |
| | | 75 | 2-3 | 120 |
| | 1457 | 110-160 | 3-4 | 160-220 |
| | | 120 | 3 | 180 |
| | | 160 | 3-4 | 230 |
| | ~1530 | 160 | 3-4 | 250 |
| | | 90 | 2-3 | 130 |
| | 1558 | 180-190 | 4-6 | 270-280 |
| | | 160-180 | 3-4 | 250 |
| | | 160 | 3-4 | 230 |

TABLE C-7

Site G - Filter in Bucket Near Tank 408

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| 07/26 | ~0900 | 150-250 | 2 | 150-250 |
| | | 200+ | 4 | 180-300 |
| | | 100-150 | 2-3 | 300 |
| 07/27 | 0840 | -† | - | 180 |
| | | | | 200 |
| | | | | 100 |
| | | | | 240 |
| | 1010 | -† | - | 120 |
| | | | | 140 |
| | | | | 100 |
| | 1143 | 200 | 2 | 120-200 |
| | | 100-150 | 3 | 120-160 |
| | | 130 | 2 | 120-160 |
| | 1306 | 200-300 | 2 | 100 |
| | | 100-200 | 3 | 100-200 |
| | | 100-200 | 2 | 100-140 |
| | 1428 | 150-200 | 3 | 100-200 |
| | | 200 | 3 | 180-200 |
| | | 200 | 3 | 160 |
| | 1530 | 130 | 2 | 100-140 |
| | | 100-130 | 2 | 80-100 |
| | | 115-130 | 3 | 100-120 |
| | ~1600 | 200 | 3-4 | 100-300 |
| | | 150-210 | 2-3 | 100-200 |
| | | 150-210 | 3 | 100-200 |
| | | 150-250 | 2-3 | 100-200 |
| 07/28 | 0820 | 200-500 | 12 | 1000+ |
| | | 300-500 | 13 | 1000+ |
| | | 300-600 | 13 | 1000+ |
| | 0847 | 600-900 | 22 | 1000+ |
| | | 800 | 18 | 1000+ |
| | | 600-900 | 12 | 1000+ |
| | ~0945 | 300 | 6 | 200-300 |
| | | 300-400 | 6-7 | 360-400 |
| | | 800(?)* | 4 | 200-300 |

†malfunction in 10.2eV PID

*rejected with >0.90 confidence

TABLE C-7 (continued)

Site G - Filter in Bucket Near Tank 408

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| | 1037 | 300 | 6 | 360-400 |
| | | 400 | 7 | 400-500 |
| | | 400 | 7-8 | 400-500 |
| | 1134 | 200-300 | 4-5 | 160-220 |
| | | 200 | 4 | 120-220 |
| | | 200 | 4 | 200 |
| | 1310 | 100-150 | 2-3 | 100-160 |
| | | 150-250 | 2-3 | 140-280 |
| | | 250-350 | 4-5 | 250-390 |
| | 1354 | 190-200 | 3-4 | 140-200 |
| | | 100-160 | 3 | 100-140 |
| | | 130-160 | 3 | 100-120 |
| | 1449 | 115 | 2-3 | 80-100 |
| | | 150-200 | 3 | 120-140 |
| | | 150-200 | 3-4 | 180-220 |
| | 1555 | 150-220 | 4-6 | 120-200 |
| | | 150-220 | 4 | 200-280 |
| | | 90-140 | 2-3 | 80-120 |

TABLE C-8

Site H - Pump at Tank 405

| Date | Time | Observed Responses | | |
|---|---|---|---|---|
| | | 10.2 eV PID | 11.7 eV PID | FID |
| 7/26 | | 100 | 3-4 | 100-150 |
| | | 50-150 | 1½-2 | 200 |
| | | 200 | 2-6 | 50-300 |
| | 1705 | 120 | 2 | 120 |
| | | 120 | 2 | 140 |
| 07/27 | 0830 | * | * | 1000+ |
| | | | | 1000+ |
| | | | | 1000+ |
| | 0949 | * | * | 1000+ |
| | | | | 1000+ |
| | | | | 1000+ |
| | 1136 | 300 | 5 | 150-260 |
| | | 200 | 5 | 240-300 |
| | | 300 | 5 | 300-380 |
| | 1300 | 300 | 3 | 240 |
| | | 250 | 3 | 280 |
| | | 200 | 3 | 160 |
| | 1426 | 200+ | 4 | 150-200 |
| | | 200+ | 3 | 150-250 |
| | | 200 | 3 | 240-300 |
| | 1530 | 30-120 | 1-2 | 20-130 |
| | | 60-90 | 1-2 | 20-100 |
| | | 30 | <1 | 20 |
| | 1613 | 80-140 | <1 | 140-160 site no longer pumping |
| 07/28 | 0822 | nothing here<br>monitored each round, but no longer pumping;<br>pump on 406 not indicating a measurable leak. | | |

*10.2 eV PID malfunction